Appendix A – GPRA07 Benefits Estimates: NEMS-GPRA07 and MARKAL-GPRA07 Baseline Cases

Overview

The Office of Energy Efficiency and Renewable Energy (EERE) programs use integrated energy models to analyze the benefits expected from successful implementation of individual programs and the EERE portfolio as a whole. The use of integrated models provides a consistent economic framework and incorporates the interactive effects among the various programs. Feedback and interactive effects result from (1) changes in energy prices resulting from lower energy consumption, (2) the interaction between supply programs affecting the mix of generation sources and the end-use sector programs affecting the demand for electricity, and (3) additional savings from reduced energy production and delivery.

A modified version of the National Energy Modeling System (NEMS)[1] was one of the models used for this benefits analysis. NEMS is an integrated energy model of the U.S. energy system that was developed by the Energy Information Administration (EIA) for forecasting and policy analysis purposes. NEMS provides projection capability to the year 2025[2] and so is used for the midterm benefits analysis. The latest version of NEMS available at the time of the benefits analysis was used as the starting point. This is a slightly updated version from *Annual Energy Outlook 2005* (AEO2005) that was setup by EIA at the request of the DOE R&D offices for use in GPRA scenarios[3]. Several modifications were subsequently made to the model by EERE to enhance its ability to represent the EERE programs. The modified version of the model is referred to as NEMS-GPRA07.

For projections beyond 2025, a modified version of the MARKAL (MARket Allocation) model was employed, referred to here as MARKAL-GPRA07. To the extent possible, the same input data and assumptions were used in MARKAL-GPRA07 as were used to generate the *AEO2005* Reference Case. MARKAL-GPRA07 was "benchmarked" to NEMS-GPRA07. While the models have some similarities, there are basic structural differences and parameter differences that will yield slightly different model results, even under the same reference conditions.

[1] *The National Energy Modeling System: An Overview 2003,* March 2003, DOE/EIA-0581(2003).
[2] For the AEO2006, NEMS projects to the year 2030.
[3] The request for the slightly modified Base Case was made under an initiative to coordinate and integrate the GPRA analyses undertaken by the various offices within DOE's Office of Energy, Science, and Environment. Formally, the request was transmitted to EIA through the Office of Fossil Energy and the National Energy Technology Laboratory's NEMS modelers.

This appendix describes the changes made to the NEMS and MARKAL models' baselines to derive the NEMS-GPRA07 and MARKAL-GPRA07 baselines, the rationale for those changes, and the resulting energy and economic projections for each model's forecast horizon. While the first section of this appendix nominally pertains to NEMS, it is relevant to MARKAL as well, because MARKAL is benchmarked to NEMS—and because the fundamental baseline changes affect both models. The second section of the appendix pertains only to the MARKAL baseline. The MARKAL section focuses on the energy and economy assumptions and projections beyond 2025.

NEMS Baseline Case Assumptions and Projections

GPRA 2007 Baseline

The first step in the benefits analysis process is to establish an appropriate Baseline Case. The EERE Baseline Case is a projection intended to represent the future U.S. energy system without the effect of EERE Programs. This Baseline Case assures that program benefits are estimated, based on the same initial forecasts for economic growth, energy prices, and levels of energy demand. It also assures that these initial assumptions are consistent with each other; e.g., that the level of electricity demand expected under the economic growth assumptions could be met at the electricity price assumed. It provides a basis for assessing how well renewable and efficiency technologies might be able to compete against future, rather than current, conventional energy technologies (e.g., more efficient central power generation). Finally, it helps ensure that underlying improvements in efficiency and renewable energy are not counted as part of the benefits of the EERE programs.

The most recent Annual Energy Outlook Reference Case is used as the starting point for developing the base case.[4] The Energy Information Administration (EIA) *Annual Energy Outlook* (AEO) Reference Case provides an independent representation of the likely evolution of energy markets. This forecast reflects expected changes in the demand for energy (e.g., to reflect the availability of new appliances), technology improvements that might improve the efficiency of energy use, and changes in energy resource production costs, including renewable energy. Energy market policies that are current at the time of the AEO's publication are included in the Base Case.[5] This approach ensures that EERE's benefits estimates do not include expected impacts of such policies. Neither the EIA Reference Case nor the EERE Base Case includes any changes in future energy policies.

Removal of EERE programs. Several adjustments are made to remove EERE programs from the EIA Reference Case. For example, EIA's estimate of rooftop photovoltaic installations

[4] As described above, the updated NEMS produces similar reference case projections as the *Annual Energy Outlook 2005* with Projections to 2025, January 2005, DOE/EIA-0383 (2005). See http://www.eia.doe.gov/oiaf/archive/aeo05/pdf/0383(2005).pdf. The Energy Information Administration's recently released Annual Energy Outlook 2006 indicates significantly higher oil and fuels prices for much of the forecast horizon than does the previous forecast (AEO 2005) on which this benefits analysis is based. All else equal, higher fuels prices would be expected to increase the market penetration of renewable energy and energy efficiency measures undertaken irrespective of DOE programs, as these technologies become more price competitive. As such, some of the nonrenewable energy savings, cost savings, and emissions reductions attributable to DOE programs might be reduced.

[5] At the publication date of *AEO 2005*, EPACT 2005 had not passed, nor had the extension of the production tax credit incentive for renewable energy generation.

resulting from the Million Solar Roofs Initiative was removed for the EERE Baseline. The improvement in distributed photovoltaic system costs was reduced. The most efficient shell improvement packages for new residential buildings were removed as well, although the impact was minimal, because they received very small market share in the AEO. Cellulosic ethanol production was assumed to not become available until after 2025 without EERE's R&D efforts.

Table A-1. Summary of Baseline Changes from the AEO2005		
	AEO2005	**GPRA07 Baseline Case**
Removal of EERE Programs		
Solar America	0.3 GW installed 2007 to 2025	Removed
Photovoltaic system costs	Significant improvement	Slower rate of improvement
Residential high efficiency shell packages	Small penetration	Removed
Cellulosic ethanol production	Commercially available by 2015	Not commercially available by 2025
Greater Technology Improvement in Base		
Solid-State Lighting	Very small improvement	Much greater improvement
Onshore Wind Performance	33% to 44% capacity factors, depending on wind class and year	35% to 53% capacity factors, depending on wind class and year
Onshore Wind Capital Costs	1% reduction over 20 years	12% to 15% reduction (depending on wind class) over 20 years
Conventional Corn ethanol production	Yield of 2.65 gallons per bushel	Yield of 2.80 gallons per bushel
Corn ethanol production with starch	Not included	Available in 2011
Hybrid Electric Vehicles	Sales share at 6% by 2025	Sales share at 1% by 2025
Energy Market Updates		
PV system size	2 kW residential, 25 kW commercial	4 kW residential, 100 kW commercial
PV maximum market share	30% for both residential and commercial	60% for residential and 55% for commercial
California PV subsidy	Not included	Included for residential systems
Corn ethanol maximum production	5.7 billion gallons	10.0 billion gallons
Structural Changes		
Offshore wind	No offshore wind technology	Offshore wind
Commercial shell efficiency	Index	Technology representation
Commercial DG algorithms		Market share and stock accounting modified

Greater Technology Improvement in the Baseline

There are a few EERE technologies that are either not represented in the *AEO2005* or their improvement is less than anticipated by the program in the absence of EERE programs. These technology assumptions were also modified for the GPRA07 Baseline.

- In commercial lighting, solid-state lighting characteristics were assumed to improve more than the very minimal improvement in the AEO2005.
- Offshore wind technology characteristics were added, and the onshore wind characteristics were modified. The onshore capital costs were assumed to decline more rapidly over time. In addition the capacity factors for each wind class were assumed to

be higher than in the *AEO2005*, although lower than the program goals. Both of these changes for onshore wind raise the projected market penetration of wind in the Baseline and shrink the benefits attributed to the EERE R&D.

- The representation of hybrid electric vehicles was modified to lower their costs over time and to gradually increase the consumer preference for hybrids. Corn ethanol with residual starch conversion was added to the EERE base that is not in the AEO. This leads to increases in ethanol yields and decreases in unit costs over time. In addition the supply curves were extended to allow up to 10 billion gallons of corn ethanol production. As a result of these changes, the EERE base has more ethanol production that the AEO.

Energy Market Updates

A few other modifications were made to reflect EERE program assumptions or updated information about energy markets. These changes affect both the Baseline and the Benefits Cases. The size of typical PV systems was increased to 4 kW in residential and 100 kW in commercial buildings to reflect recent PV installation experience and trends. The maximum market for PV systems was increased from 30% to 55% in the commercial sector and to 60% for residential PVs. Similarly, the maximum market share for gas-fired distributed generation technologies was increased from 30% to 50% in the commercial sector. California PV credits were incorporated in the Pacific region.

Structural Changes

In a few cases, we made structural changes to improve the model's representation of markets important to EERE technologies.

- Offshore wind was added as another technology option with resources available in the coastal regions and the regions around the Great Lakes.
- The shell indices in the commercial module were replaced with a technology choice algorithm necessary for later representation of EERE shell technologies. In addition, alterations to the distributed generation algorithm in the building modules were made to reflect market adoption data gathered by Lawrence Berkeley National Laboratory, to account for buildings that have already installed a DG technology in prior years, and to allow greater than an annual 0.5% adoption in existing buildings.

A summary of these modifications is provided in **Table A-4**. Greater detail can be found in the individual program appendices.

GPRA07 Baseline

In the Baseline projections, oil prices are projected to fall and then gradually increase through 2025, as shown in **Figure A-1**. Natural gas prices follow a similar pattern. Coal prices, on the other hand, are projected to be relatively constant in real terms, with a very slight decline. Electricity prices are projected to experience a decrease through 2010 and then increase gradually.

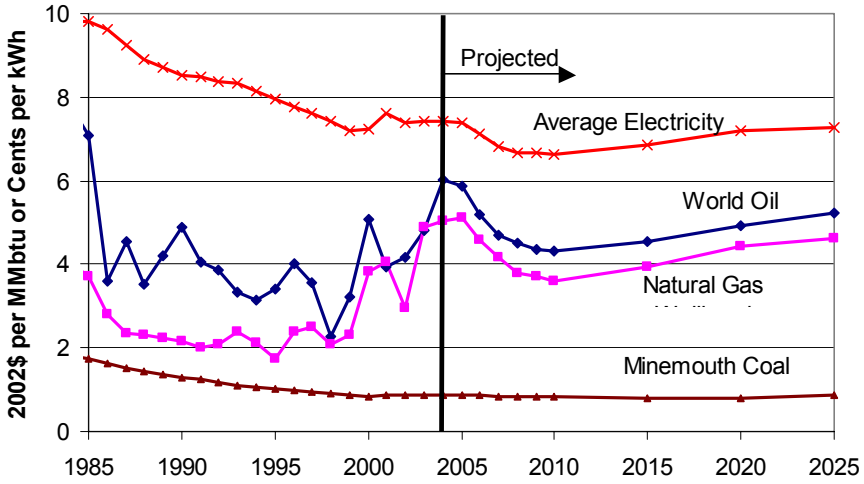


Figure A-1. Projected Energy Prices

The resulting Baseline Case projects a 30% increase in conventional energy demand from 2005 to 2025.[6] Energy efficiency and renewable energy improvements, however, contribute toward a 28% reduction in conventional energy intensity (energy used per dollar of GPD produced) over the same period (**Figure 2**).[7] Between 2005 and 2025, renewable energy technology improvements result in increases in renewable electric generation in central and distributed applications of roughly 180 billion kWh, which is an almost 50 % increase in nonhydroelectric generation.

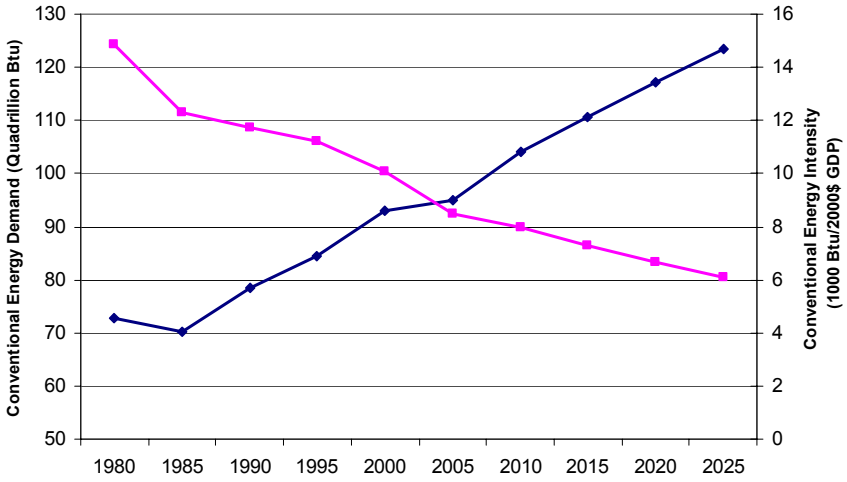


Figure A-2. U.S. Conventional Energy Demand and Energy Intensity

[6] Very similar to the *AEO2005*.

[7] Energy intensity changes result from a mix of structural changes in the economy (e.g., growing service sector) and efficiency improvements. Two recent EERE-sponsored studies provide additional background on understanding the sources of changes to our energy intensity: Ortiz and Sollinger, *Shaping Our Future by Reducing Energy Intensity in the U.S. Economy; Volume 1: Proceedings of the Conference* (2003, Rand Corporation); and Bernstein, Fonkych, Loeb, and Loughran, "State-Level Changes in Energy Intensity and their National Implications" (2003, Rand Corporation).

NEMS-GPRA07 Baseline Tables A-1 Through A-6

Table A-1. Total Energy Supply and Disposition Summary
(Quadrillion Btu per Year, Unless Otherwise Noted)

	2010	2015	2020	2025
Production				
Crude Oil & Lease Condensate	12.74	11.63	10.99	10.00
Natural Gas Plant Liquids	2.65	2.66	2.78	2.79
Dry Natural Gas	20.90	21.23	22.36	22.29
Coal	25.12	25.54	26.86	29.48
Nuclear Power	8.46	8.59	8.64	8.64
Renewable Energy 1/	6.81	7.23	8.11	9.14
Other 2/	1.02	0.83	0.83	1.28
Total	77.72	77.70	80.56	83.61
Imports				
Crude Oil 3/	24.69	29.00	32.49	35.08
Petroleum Products 4/	6.01	6.23	6.61	7.53
Natural Gas	5.77	8.02	8.82	9.68
Other Imports 5/	0.92	1.07	1.15	1.23
Total	37.39	44.32	49.07	53.51
Exports				
Petroleum 6/	2.15	2.21	2.26	2.32
Natural Gas	0.65	0.81	0.86	0.83
Coal	1.06	0.88	0.89	0.67
Total	3.86	3.89	4.01	3.81
Discrepancy 7/	0.02	-0.11	-0.06	-0.10
Consumption				
Petroleum Products 8/	44.85	48.05	51.29	54.23
Natural Gas	26.10	28.61	30.50	31.33
Coal	24.98	25.68	27.10	30.04
Nuclear Power	8.46	8.59	8.64	8.64
Renewable Energy 1/	6.82	7.23	8.11	9.14
Other 9/	0.03	0.08	0.05	0.04
Total	111.23	118.24	125.68	133.42
Net Imports - Petroleum	28.55	33.02	36.84	40.28
Prices (2003 dollars per unit)				
World Oil Price ($ per bbl) 10/	25.00	26.75	28.50	30.31
Gas Wellhead Price ($ / Mcf) 11/	3.68	4.17	4.55	4.75
Coal Minemouth Price ($ / ton)	17.32	16.85	17.13	18.60
Electricity (cents / Kwh)	6.63	6.94	7.20	7.26

1/ Includes grid-connected electricity from conventional hydroelectric; wood and wood waste; landfill gas; municipal solid waste; other biomass; wind; photovoltaic and solar thermal sources; non-electric energy from renewable sources, such as active and passive solar systems, and wood; and both the ethanol and gasoline components of E85, but not the ethanol components of blends less than 85 percent. Excludes electricity imports using renewable sources and nonmarketed renewable energy.

2/ Includes liquid hydrogen, methanol, supplemental natural gas, and some domestic inputs to refineries.

3/ Includes imports of crude oil for the Strategic Petroleum Reserve.

4/ Includes imports of finished petroleum products, unfinished oils, alcohols, ethers, and blending components.

5/ Includes coal, coal coke (net), and electricity (net).

6/ Includes crude oil and petroleum products.

7/ Balancing item. Includes unaccounted for supply, losses, gains, net storage withdrawals, heat loss when natural gas is converted to liquid fuel, and heat loss when coal is converted to liquid fuel.

8/ Includes natural gas plant liquids, crude oil consumed as a fuel, and nonpetroleum-based liquids for blending, such as ethanol.

9/ Includes net electricity imports, methanol, and liquid hydrogen.

10/ Average refiner acquisition cost for imported crude oil.

11/ Represents lower 48 onshore and offshore supplies.

Table A-2. Energy Consumption by Sector and Source
(Quadrillion Btu per Year, Unless Otherwise Noted)

Energy Consumption	2010	2015	2020	2025
Residential				
Distillate Fuel	0.89	0.87	0.82	0.77
Kerosene	0.09	0.09	0.09	0.09
Liquefied Petroleum Gas	0.57	0.61	0.64	0.67
Petroleum Subtotal	1.56	1.57	1.56	1.52
Natural Gas	5.68	5.90	6.05	6.16
Coal	0.01	0.01	0.01	0.01
Renewable Energy 1/	0.40	0.39	0.39	0.38
Electricity	5.02	5.40	5.79	6.18
Delivered Energy	12.66	13.28	13.79	14.25
Electricity Related Losses	10.79	11.29	11.83	12.46
Total	23.45	24.57	25.62	26.71
Commercial				
Distillate Fuel	0.61	0.65	0.70	0.75
Residual Fuel	0.07	0.07	0.08	0.08
Kerosene	0.03	0.03	0.03	0.03
Liquefied Petroleum Gas	0.10	0.10	0.11	0.11
Motor Gasoline 2/	0.04	0.04	0.04	0.04
Petroleum Subtotal	0.85	0.90	0.95	1.00
Natural Gas	3.47	3.69	3.96	4.27
Coal	0.10	0.10	0.10	0.10
Renewable Energy 3/	0.09	0.09	0.09	0.09
Electricity	4.99	5.62	6.29	7.07
Delivered Energy	9.50	10.39	11.38	12.52
Electricity Related Losses	10.74	11.74	12.87	14.25
Total	20.23	22.13	24.25	26.77
Industrial 4/				
Distillate Fuel	1.04	1.08	1.14	1.19
Liquefied Petroleum Gas	2.30	2.44	2.59	2.73
Petrochemical Feedstocks	1.48	1.52	1.55	1.56
Residual Fuel	0.34	0.38	0.38	0.37
Motor Gasoline 2/	0.31	0.33	0.35	0.37
Other Petroleum 5/	4.68	4.69	5.01	5.20
Petroleum Subtotal	10.16	10.44	11.02	11.43
Natural Gas	8.12	8.50	8.91	9.43
Lease and Plant Fuel 6/	1.20	1.22	1.32	1.30
Natural Gas Subtotal	9.32	9.73	10.22	10.73
Metallurgical Coal	0.55	0.48	0.42	0.37
Steam Coal	1.42	1.42	1.42	1.42
Net Coal Coke Imports	0.06	0.05	0.05	0.05
Coal Subtotal	2.03	1.95	1.89	1.83
Renewable Energy 7/	2.07	2.19	2.34	2.49
Electricity	3.78	3.98	4.19	4.40
Delivered Energy	27.36	28.28	29.67	30.89
Electricity Related Losses	8.13	8.31	8.58	8.87
Total	35.49	36.59	38.24	39.75

1/ Includes wood used for residential heating.
2/ Includes ethanol (blends of 10 percent or less) and ethers blended into gasoline.
3/ Includes commercial sector consumption of wood and wood waste, landfill gas, municipal solid waste, and other biomass for combined heat and power.
4/ Includes energy for combined heat and power plants, except those whose primary business is to sell electricity, or electricity and heat, to the public.
5/ Includes petroleum coke, asphalt, road oil, lubricants, still gas, and miscellaneous petroleum products.
6/ Represents natural gas used in the field gathering and processing plant machinery.
7/ Includes consumption of energy from hydroelectric, wood and wood waste, municipal solid waste, and other biomass.

Table A-2. Energy Consumption by Sector and Source (Continued)

	2010	2015	2020	2025
Transportation				
Distillate Fuel 8/	6.95	7.66	8.33	9.02
Jet Fuel 9/	4.04	4.45	4.74	4.89
Motor Gasoline 2/	19.16	20.81	22.28	23.98
Residual Fuel	0.56	0.57	0.58	0.58
Liquefied Petroleum Gas	0.06	0.07	0.08	0.09
Other Petroleum 10/	0.26	0.27	0.29	0.31
Petroleum Subtotal	31.02	33.83	36.30	38.87
Pipeline Fuel Natural Gas	0.70	0.73	0.82	0.84
Compressed Natural Gas	0.06	0.08	0.10	0.12
Renewable Energy (E85) 11/	0.00	0.00	0.00	0.00
Liquid Hydrogen	0.00	0.00	0.00	0.00
Electricity	0.09	0.10	0.11	0.12
Delivered Energy	31.87	34.74	37.34	39.95
Electricity Related Losses	0.19	0.21	0.22	0.24
Total	32.06	34.95	37.56	40.19
Electric Power 14/				
Distillate Fuel	0.40	0.40	0.48	0.45
Residual Fuel	0.86	0.92	0.98	0.96
Petroleum Subtotal	1.26	1.32	1.46	1.41
Natural Gas	6.87	8.47	9.35	9.22
Steam Coal	22.84	23.63	25.10	28.11
Nuclear Power	8.46	8.59	8.64	8.64
Renewable Energy/Other 15/	4.26	4.56	5.29	6.17
Electricity Imports	0.03	0.08	0.05	0.04
Total	43.72	46.64	49.88	53.58
Total Energy Consumption				
Distillate Fuel	9.89	10.66	11.47	12.18
Kerosene	0.14	0.14	0.14	0.13
Jet Fuel 9/	4.04	4.45	4.74	4.89
Liquefied Petroleum Gas	3.04	3.22	3.42	3.60
Motor Gasoline 2/	19.51	21.18	22.67	24.39
Petrochemical Feedstocks	1.48	1.52	1.55	1.56
Residual Fuel	1.84	1.94	2.01	1.99
Other Petroleum 12/	4.92	4.94	5.29	5.49
Petroleum Subtotal	44.85	48.05	51.29	54.23
Natural Gas	24.20	26.65	28.36	29.20
Lease and Plant Fuel 6/	1.20	1.22	1.32	1.30
Pipeline Natural Gas	0.70	0.73	0.82	0.84
Natural Gas Subtotal	26.10	28.61	30.50	31.33
Metallurgical Coal	0.55	0.48	0.42	0.37
Steam Coal	24.37	25.15	26.62	29.63
Net Coal Coke Imports	0.06	0.05	0.05	0.05
Coal Subtotal	24.98	25.68	27.10	30.04
Nuclear Power	8.46	8.59	8.64	8.64
Renewable Energy 16/	6.82	7.23	8.11	9.14
Liquid Hydrogen	0.00	0.00	0.00	0.00
Electricity Imports	0.03	0.08	0.05	0.04
Total	111.23	118.24	125.68	133.42

2/ Includes ethanol (blends of 10 percent or less) and ethers blended into gasoline.
6/ Represents natural gas used in the field gathering and processing plant machinery.
8/ Diesel fuel containing 500 parts per million (ppm) or 15 ppm sulfur.
9/ Includes only kerosene type.
10/ Includes aviation gasoline and lubricants.
11/ E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol actually varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.
12/ Includes unfinished oils, natural gasoline, motor gasoline blending components, aviation gasoline, lubricants, still gas, asphalt, road oil, petroleum coke, and miscellaneous petroleum products.
13/ Includes electricity generated for sale to the grid and for own use from renewable sources, and non-electric energy from renewable sources. Excludes nonmarketed renewable energy consumption for geothermal heat pumps, buildings photovoltaic systems, and solar thermal hot water heaters.
14/ Includes consumption of energy by electricity-only and combined heat and power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public. Includes small power producers and exempt wholesale generators.
15/ Includes conventional hydroelectric, geothermal, wood and wood waste, municipal solid waste, other biomass, petroleum coke, wind, photovoltaic and solar thermal sources. Excludes net electricity imports.
16/ Includes hydroelectric, geothermal, wood and wood waste, municipal solid waste, other biomass, wind, photovoltaic and solar thermal sources. Includes ethanol components of E85; excludes ethanol blends (10 percent or less) in motor gasoline. Excludes net electricity imports and nonmarketed renewable energy consumption for geothermal

Table A-3. Energy Prices by Sector and Source
(2003 Dollars per Million Btu, Unless Otherwise Noted)

	2010	2015	2020	2025
Residential	14.38	15.00	15.66	16.09
Primary Energy 1/	8.38	8.75	9.20	9.60
Petroleum Products 2/	10.41	10.76	11.34	11.94
Distillate Fuel	8.24	8.48	8.84	9.12
Liquefied Petroleum Gas	14.23	14.44	14.98	15.62
Natural Gas	7.84	8.23	8.66	9.04
Electricity	23.03	23.66	24.16	24.16
Commercial	13.83	14.85	15.63	16.00
Primary Energy 1/	6.84	7.21	7.54	7.79
Petroleum Products 2/	7.11	7.28	7.56	7.84
Distillate Fuel	6.26	6.48	6.77	7.06
Residual Fuel	4.26	4.52	4.80	5.08
Natural Gas	6.91	7.34	7.68	7.92
Electricity	20.01	21.22	22.06	22.23
Industrial 3/	6.87	7.25	7.74	8.08
Primary Energy	5.55	5.83	6.24	6.60
Petroleum Products 2/	7.23	7.42	7.81	8.34
Distillate Fuel	6.75	7.18	7.40	7.73
Liquefied Petroleum Gas	9.99	10.23	10.64	11.33
Residual Fuel	3.87	4.10	4.33	4.62
Natural Gas 4/	4.41	4.83	5.25	5.43
Metallurgical Coal	1.82	1.76	1.75	1.68
Steam Coal	1.56	1.55	1.56	1.62
Electricity	13.91	14.65	15.52	15.67
Transportation	10.90	10.94	11.15	11.44
Primary Energy	10.88	10.92	11.12	11.41
Petroleum Products 2/	10.88	10.92	11.13	11.41
Distillate Fuel 5/	10.71	10.69	10.70	10.84
Jet Fuel 6/	6.23	6.29	6.56	6.93
Motor Gasoline 7/	12.25	12.26	12.50	12.78
Residual Fuel	3.74	4.01	4.28	4.56
Liquefied Petroleum Gas 8/	15.23	15.28	15.59	16.19
Natural Gas 9/	8.59	9.11	9.44	9.66
Ethanol (E85) 10/	16.86	16.90	17.14	16.88
Electricity	18.92	19.66	20.04	19.92

1/ Weighted average price includes fuels below as well as coal.
2/ This quantity is the weighted average for all petroleum products, not just those listed below.
3/ Includes energy for combined heat and power plants, except those whose primary business is to sell electricity, or electricity and heat, to the public.
4/ Excludes use for lease and plant fuel.
5/ Diesel fuel containing 500 parts per million (ppm) or 15 ppm sulfur. Price includes Federal and State taxes while excluding county and local taxes.
6/ Kerosene-type jet fuel. Price includes Federal and State taxes while excluding county and local taxes.
7/ Sales weighted-average price for all grades. Includes Federal, State, and local taxes.
8/ Includes Federal and State taxes while excluding county and local taxes.
9/ Compressed natural gas used as a vehicle fuel. Price includes estimated motor vehicle fuel taxes.
10/ E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol actually varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.

Table A-3. Energy Prices by Sector and Source (Continued)

	2010	2015	2020	2025
Average End-Use Energy	10.55	10.95	11.41	11.77
Primary Energy	8.59	8.83	9.16	9.51
Electricity	19.44	20.35	21.12	21.26
Electric Power 11/				
Fossil Fuel Average	2.07	2.28	2.43	2.43
Petroleum Products	4.55	4.77	5.12	5.43
Distillate Fuel	5.34	5.52	5.96	6.34
Residual Fuel	4.19	4.44	4.71	5.00
Natural Gas	4.32	4.81	5.20	5.38
Steam Coal	1.25	1.23	1.24	1.32
Average Price to All Users 12/				
Petroleum Products 2/	9.87	10.00	10.27	10.64
Distillate Fuel	9.49	9.70	9.80	10.03
Jet Fuel	6.23	6.29	6.56	6.93
Liquefied Petroleum Gas	10.97	11.21	11.65	12.32
Motor Gasoline 7/	12.24	12.25	12.49	12.77
Residual Fuel	3.99	4.25	4.52	4.80
Natural Gas	5.56	5.94	6.32	6.56
Coal	1.27	1.25	1.26	1.33
Ethanol (E85) 10/	16.86	16.90	17.14	16.88
Electricity	19.44	20.35	21.12	21.26
Non-Renewable Energy Expenditures by Sector (billion 2003 dollars)				
Residential	176.3	193.3	209.8	223.2
Commercial	130.1	153.0	176.6	199.0
Industrial	140.1	152.6	169.9	185.1
Transportation	339.7	372.2	407.2	447.2
Total Non-Renewable Expenditures	786.2	871.1	963.5	1054.4
Transportation Renewable Expenditures	0.0	0.0	0.1	0.1
Total Expenditures	786.3	871.2	963.5	1054.5

2/ This quantity is the weighted average for all petroleum products, not just those listed below.

7/ Sales weighted-average price for all grades. Includes Federal, State, and local taxes.

10/ E85 refers to a blend of 85 percent ethanol (renewable) and 15 percent motor gasoline (nonrenewable). To address cold starting issues, the percentage of ethanol actually varies seasonally. The annual average ethanol content of 74 percent is used for this forecast.

11/ Includes electricity-only and combined heat and power plants whose primary business is to sell electricity, or electricity and heat, to the public.

12/ Weighted averages of end-use fuel prices are derived from the prices shown in each sector and the corresponding sectoral consumption.

Table A-4. Electricity Supply, Disposition, Prices, and Emissions
(Billion Kilowatthours, Unless Otherwise Noted)

	2010	2015	2020	2025
Generation by Fuel Type				
Electric Power Sector 1/				
Power Only 2/				
Coal	2171	2248	2418	2786
Petroleum	111	117	128	123
Natural Gas 3/	635	844	1000	1000
Nuclear Power	810	823	827	827
Pumped Storage/Other	-9	-9	-9	-9
Renewable Sources 4/	386	408	462	527
Distributed Generation (Natural Gas)	0	0	1	3
Total	4106	4432	4828	5258
Combined Heat and Power 5/				
Coal	33	33	33	33
Petroleum	6	7	8	7
Natural Gas	187	201	193	183
Renewable Sources	4	4	4	4
Total	230	245	238	227
Total Net Generation	4336	4676	5067	5486
Less Direct Use	66	65	65	65
Net Available to the Grid	4270	4611	5001	5420
Commercial and Industrial Generation 6/				
Coal	21	21	21	21
Petroleum	9	10	12	12
Natural Gas	101	121	150	186
Other Gaseous Fuels 7/	4	5	5	5
Renewable Sources 4/	43	45	49	54
Other 8/	10	10	10	10
Total	188	212	247	288
Less Direct Use	140	153	173	198
Total Sales to the Grid	48	59	74	90
Total Electricity Generation	4523	4888	5314	5774
Total Net Generation to the Grid	4318	4670	5076	5511

1/ Includes electricity-only and combined heat and power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public.
2/ Includes plants that only produce electricity.
3/ Includes electricity generation from fuel cells.
4/ Includes conventional hydroelectric, geothermal, wood, wood waste, municipal solid waste, landfill gas, other biomass, solar, and wind power.
5/ Includes combined heat and power plants whose primary business is to sell electricity and heat to the public (i.e., those that report NAICS code 22).
6/ Includes combined heat and power plants and electricity-only plants in the commercial and industrial sectors; and small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
7/ Other gaseous fuels include refinery and still gas.
8/ Other includes batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.

Table A-4. Electricity Supply, Disposition, Prices, and Emissions (Continued)

	2010	2015	2020	2025
Net Imports	10	22	16	11
Electricity Sales by Sector				
Residential	1470	1584	1696	1812
Commercial	1463	1646	1845	2072
Industrial	1107	1166	1229	1290
Transportation	26	29	32	35
Total	4067	4424	4801	5208
Direct Use	205	218	238	264
Total Consumption	4273	4643	5039	5472
End-Use Prices 9/ (2003 cents per kilowatthour)				
Residential	7.9	8.1	8.2	8.2
Commercial	6.8	7.2	7.5	7.6
Industrial	4.7	5.0	5.3	5.3
Transportation	6.5	6.7	6.8	6.8
All Sectors Average	6.6	6.9	7.2	7.3
Prices by Service Category 9/ (2003 cents per kilowatthour)				
Generation	4.1	4.5	4.7	4.8
Transmission	0.6	0.6	0.7	0.7
Distribution	2.0	1.9	1.8	1.8
Electric Power Sector Emissions 1/				
Sulfur Dioxide (million tons)	9.3	9.0	9.0	8.9
Nitrogen Oxide (million tons)	4.0	4.1	4.2	4.3
Mercury (tons)	54.4	55.2	55.7	55.5

1/ Includes electricity-only and combined heat and power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public.

9/ Prices represent average revenue per kilowatthour.

Table A-5. Electricity Generating Capacity
(Gigawatts)

	2010	2015	2020	2025
Electric Power Sector 2/				
Power Only 3/				
Coal Steam	305.1	310.3	331.6	383.1
Other Fossil Steam 4/	119.4	98.8	97.8	97.2
Combined Cycle	136.2	146.9	172.6	185.5
Combustion Turbine/Diesel	132.5	141.4	164.7	183.8
Nuclear Power 5/	100.6	102.2	102.7	102.7
Pumped Storage	20.9	20.9	20.9	20.9
Fuel Cells	0.0	0.0	0.0	0.0
Renewable Sources 6/	95.0	100.0	113.1	128.1
Distributed Generation (Natural Gas) 7/	0.4	1.0	2.7	6.2
Total	910.0	921.6	1006.0	1107.5
Combined Heat and Power 8/				
Coal Steam	5.1	5.0	5.0	5.0
Other Fossil Steam 4/	1.1	1.1	1.1	1.1
Combined Cycle	33.5	33.5	33.5	33.5
Combustion Turbine/Diesel	5.1	5.1	5.1	5.1
Renewable Sources 6/	0.3	0.3	0.3	0.3
Total	45.1	45.0	45.0	45.0
Cumulative Planned Additions 9/				
Coal Steam	1.8	1.8	1.8	1.8
Other Fossil Steam 4/	0.0	0.0	0.0	0.0
Combined Cycle	28.3	28.3	28.3	28.3
Combustion Turbine/Diesel	3.9	3.9	3.9	3.9
Nuclear Power	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0
Renewable Sources 6/	2.7	2.8	2.9	3.0
Distributed Generation 7/	0.0	0.0	0.0	0.0
Total	36.7	36.8	36.9	37.0
Cumulative Unplanned Additions 9/				
Coal Steam	0.0	5.8	27.0	78.5
Other Fossil Steam 4/	0.0	0.0	0.0	0.0
Combined Cycle	3.3	14.6	40.3	53.2
Combustion Turbine/Diesel	5.8	19.1	44.7	65.2
Nuclear Power	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0
Renewable Sources 6/	0.1	5.0	18.0	33.0
Distributed Generation 7/	0.4	1.0	2.7	6.2
Total	9.7	45.6	132.7	236.1
Cumulative Electric Power Sector Additions	46.3	82.3	169.6	273.0
Cumulative Retirements 10/				
Coal Steam	1.9	2.5	2.5	2.5
Other Fossil Steam 4/	9.3	29.8	30.8	31.4
Combined Cycle	0.1	0.7	0.7	0.7
Combustion Turbine/Diesel	1.9	6.3	8.6	9.9
Nuclear Power	0.0	0.0	0.0	0.0
Pumped Storage	0.0	0.0	0.0	0.0
Fuel Cells	0.0	0.0	0.0	0.0
Renewable Sources 6/	0.1	0.1	0.1	0.1
Total	13.3	39.4	42.7	44.6
Total Electric Power Sector Capacity	955.1	966.6	1051.0	1152.5

Table 5. Electricity Generating Capacity (Continued)

Commercial and Industrial Generators 11/				
Coal	4.1	4.1	4.1	4.1
Petroleum	1.5	1.5	1.6	1.7
Natural Gas	17.5	20.2	24.1	29.0
Other Gaseous Fuels	1.5	1.6	1.6	1.7
Renewable Sources 6/	7.0	7.4	8.0	9.4
Other	0.7	0.7	0.7	0.7
Total	32.3	35.5	40.3	46.6
Cumulative Capacity Additions 9/	5.1	8.3	13.0	19.3

1/ Net summer capacity is the steady hourly output that generating equipment is expected to supply to

Table 6. Renewable Energy Generating Capacity and Generation
(Gigawatts, Unless Otherwise Noted)

	2010	2015	2020	2025
Electric Power Sector 1/				
Net Summer Capacity				
Conventional Hydropower	0.8	0.9	0.8	0.6
Geothermal 2/	5.2	4.6	4.4	4.1
Municipal Solid Waste 3/	11.3	13.3	14.9	16.1
Wood and Other Biomass 4/	11.3	13.3	14.9	16.1
Solar Thermal	0.0	0.0	0.0	0.0
Solar Photovoltaic 5/	0.0	0.0	0.0	0.0
Wind	17.3	18.8	20.1	20.8
Total	0.0	0.0	0.0	0.0
Generation (billion kilowatthours)				
Conventional Hydropower	2.0	1.8	1.8	2.1
Geothermal 2/	0.6	0.8	0.9	1.0
Municipal Solid Waste 3/	0.5	0.5	0.6	0.6
Wood and Other Biomass 4/	1.0	1.0	1.1	1.1
Dedicated Plants	1.1	1.4	1.5	1.6
Cofiring	0.6	0.5	0.5	0.9
Solar Thermal	0.0	0.0	0.0	0.0
Solar Photovoltaic	0.0	0.0	0.0	0.0
Wind	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	0.0
End Use Sector				
Net Summer Capacity				
Combined Heat and Power				
Municipal Solid Waste	4.7	5.1	5.5	5.8
Biomass	0.8	0.8	0.9	0.9
Total	5.3	5.4	5.7	6.0
Other End-Use Generators 6/				
Conventional Hydropower 7/	23.0	24.7	26.3	27.8
Geothermal	0.0	0.0	0.0	0.0
Solar Photovoltaic 5/	0.0	0.0	0.0	0.0
Total	0.0	0.0	0.0	0.0
Generation (billion kwh)				
Combined Heat and Power				
Municipal Solid Waste	0.6	0.6	0.7	0.6
Biomass	23.0	24.7	26.3	27.8
Total	0.0	0.0	0.0	0.0
Other End-Use Generators 6/	0.0	0.0	0.0	0.0
Conventional Hydropower 7/	0.0	0.0	0.0	0.0
Geothermal	25.0	26.8	28.5	30.3
Solar Photovoltaic	0.6	0.6	0.6	0.7
Total	0.0	0.0	0.0	0.0

1/ Includes electricity-only and combined heat and power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public.
2/ Includes hydrothermal resources only (hot water and steam).
3/ Includes landfill gas.
4/ Includes projections for energy crops after 2010.
5/ Does not include off-grid photovoltaics (PV). EIA estimates that another 76 megawatts of remote electricity generation PV applications were in service in 1999, plus an additional 205 megawatts in communications, transportation, and assorted other non-grid-connected applications.
6/ Includes small on-site generating systems in the residential, commercial, and industrial sectors used primarily for own-use generation, but which may also sell some power to the grid.
7/ Represents own-use industrial hydroelectric power.

MARKAL Baseline Case Assumptions and Projections

Economic and Demographic Assumptions

The Baseline Case used to evaluate the impact of the EERE portfolio was benchmarked to EIA's *Annual Energy Outlook 2005* (*AEO2005*) for the period between 2005 and 2025.[8] To the extent possible, the same input data and assumptions were used in MARKAL-GPRA07, as were used to generate the *AEO2005* Reference Case. For example, the macroeconomic projections for GDP, housing stock, commercial square footage, industrial output, and vehicle miles traveled were taken from the *AEO2005*. At the sector level, both supply-side and demand-side technologies were characterized to reflect the *AEO2005* assumptions where the representation of technologies is similar between MARKAL (MARKet ALlocation) and the National Energy Modeling System (NEMS). The resulting projections track closely with the *AEO2005* at the aggregate level, although they do not match exactly at the end-use level. For the period after 2025, various sources were used to compile a set of economic and technical assumptions. For instance, the primary economic drivers of GDP and population were based on the real GDP growth rate from the Congressional Budget Office's *Long-Term Budget Outlook* and population growth rates from the Social Security Administration's 2005 *Annual Report* to the Board of Trustees low-cost assumptions.[9]

In the reference case, GDP is projected to increase at an average annual rate of 3% from 2005 to 2025, and then slow to an average annual rate of 2.2% from 2025 to 2050. The population growth rate is projected to decline from an average annual rate of 0.8% between 2005 and 2025 to 0.5% from 2025 to 2050. The reference case macroeconomic assumptions are shown in **Table A-7.**

Table A-7. Reference Case Macroeconomic and Demographic Assumptions

											Annual Growth Rates		
	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'05-'25	25-'50	'05-'50
GDP (Bill. 2001$)	$11,490	$13,398	$15,581	$18,057	$20,779	$23,625	$26,534	$29,584	$32,651	$35,961	3.0%	2.2%	2.6%
Population (Million)	296.8	310.1	323.5	337.0	350.6	362.6	373.3	381.8	387.7	393.1	0.8%	0.5%	0.6%
Total Households (Million)	115.0	122.0	129.1	135.8	142.5	145.0	149.3	152.7	155.1	157.2	1.1%	0.4%	0.7%
Commercial Floorspace (Bill. sq ft)	74.7	81.2	88.4	96.2	104.8	112.9	120.8	128.7	136.3	144.1	1.7%	1.3%	1.5%
Industrial Production (2000=100)	96	108	120	133	148	167	185	205	225	245	2.2%	2.0%	2.1%
Light Duty Vehicle Miles Traveled (Bill. VMT)	2,667	3,017	3,354	3,680	4,053	4,377	4,680	4,929	5,106	5,272	2.1%	1.1%	1.5%

[8] The Energy Information Administration's recently released *Annual Energy Outlook 2006* (Early Release) indicates significantly higher oil and fuels prices for much of the forecast horizon than does the previous forecast (*AEO 2005*), on which this benefits analysis is based. *All else equal*, higher fuels prices would be expected to increase the market penetration of renewable energy and energy efficiency measures undertaken irrespective of DOE programs, as these technologies become more price competitive. As such, some of the nonrenewable energy savings, cost savings, and emissions reductions attributable to DOE programs might be reduced.

[9] *The Long-Term Budget Outlook,* Congressional Budget Office, December 2003.
The 2005 Annual Report of the Board of Trustees of the Federal Old Age and Survivors Insurance and the Federal Disability Insurance Trust Funds, March 2005.

Assumptions on Energy Prices

Table A-8 shows projected energy prices for the reference case. Real natural gas prices are projected to drop between 2005 and 2010, and then increase at nearly 1.7% per year from 2010 to 2025 before increasing amounts of arctic gas and LNG imports limit the average annual increase to 0.8% from 2025 to 2050. Real crude oil prices are also projected to decrease between 2000 and 2005, increase at average annual rates of 1.3% between 2010 and 2025, and 1% per year thereafter.

Average real mine mouth coal prices are projected to continue to decline by about 1% a year between 2005 and 2015, due to increasing productivity gains and a continued shift to less labor intensive Western coal production. However, coal prices are projected to increase at an average rate of 1% per year after 2015, due to increased demands, gradually increasing mine depths, and a saturation of labor productivity gains.

Table A-8. Reference Case Energy Prices

											Annual Growth Rates		
2003 $s	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'05-'25	25-'50	'05-'50
World Oil Price ($/bbl)	$33.65	$24.73	$26.42	$28.11	$29.94	$31.89	$33.91	$34.75	$36.51	$38.40	-0.6%	1.0%	0.3%
Natural Gas Wellhead Price ($/Mcf)	$5.10	$3.63	$4.31	$4.52	$4.66	$4.41	$4.63	$4.87	$5.12	$5.68	-0.4%	0.8%	0.2%
Coal Minemouth Price ($/short ton)	$18.49	$17.17	$16.72	$17.22	$18.17	$19.45	$20.95	$22.57	$23.49	$24.00	-0.1%	1.1%	0.6%

Primary Energy Consumption

As a result of slightly increasing energy prices relative to technology improvements and shifts within the economy, energy demand is projected to increase more slowly than GDP. As shown in **Table A-9**, total primary energy use is projected to increase at a rate of 1.3% per year from 2005 to 2025, and at an average annual rate of 0.5% between 2025 and 2050. By 2050, total primary energy consumption is projected to reach just under 150 quadrillion Btus (quads). Overall, the energy consumption to GDP ratio is projected to decline by 1.7% per year from 2005 to 2050, while total carbon emissions increase by 1.1% per year over the same period.

Table A-9. Primary Energy Consumption, Energy Intensity, and Carbon Emissions

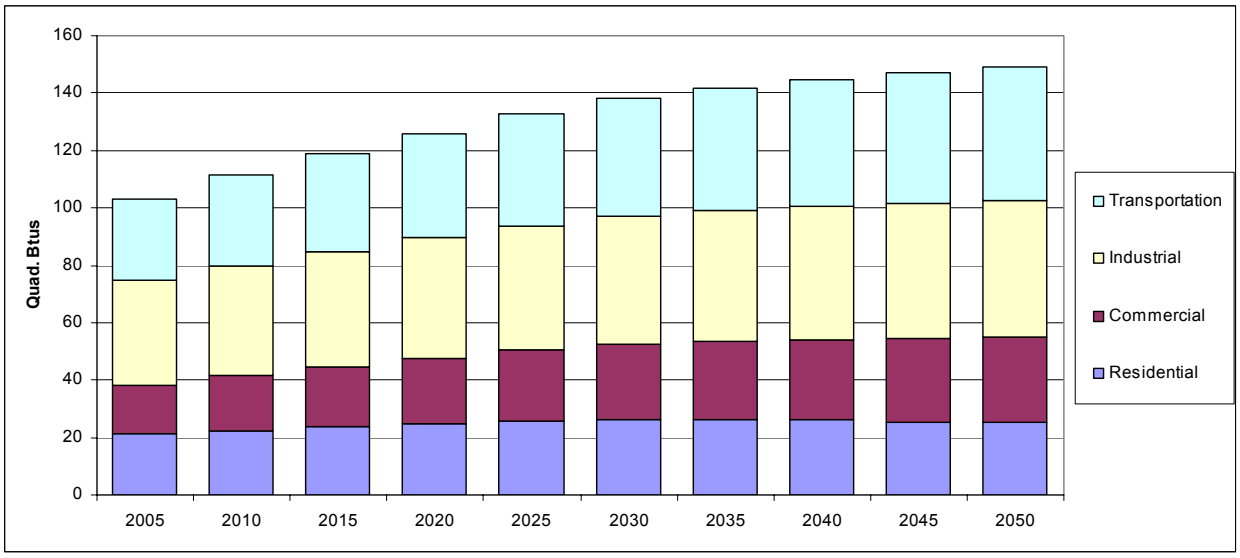
											Annual Growth Rates		
	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	'05-'25	25-'50	'05-'50
Petroleum	40.6	44.5	47.2	49.5	52.1	54.0	55.4	56.9	58.5	60.7	1.3%	0.6%	0.9%
Natural Gas	23.4	27.4	29.1	31.1	32.7	33.0	33.7	35.3	36.7	37.7	1.7%	0.6%	1.1%
Coal	24.0	23.9	26.1	28.1	30.2	33.0	35.3	35.5	35.9	35.1	1.2%	0.6%	0.8%
Nuclear	8.4	8.4	8.6	8.6	8.6	8.6	6.6	6.0	4.2	2.7	0.1%	-4.5%	-2.5%
Renewables	7.2	7.7	8.3	9.1	9.8	10.2	11.2	11.6	12.4	13.4	1.5%	1.3%	1.4%
Total Primary Energy	**103.6**	**111.8**	**119.3**	**126.4**	**133.5**	**138.8**	**142.3**	**145.3**	**147.7**	**149.7**	**1.3%**	**0.5%**	**0.8%**
Energy/GDP (Thos. Btu/ '01$ GDP)	9.0	8.3	7.7	7.0	6.4	5.9	5.4	4.9	4.5	4.2	-1.7%	-1.7%	-1.7%
Carbon Emissions (MMT)	1,657	1,835	1,983	2,130	2,274	2,347	2,454	2,549	2,634	2,714	1.6%	0.7%	1.1%

Crude oil's share of total energy consumption is projected to increase from 39% in 2005 to nearly 41% in 2050. The natural gas share is projected to grow from 23% to 25% over the same period. Coal generation is projected to increase slightly from a 23% share in 2005 to nearly 24% in 2050. Almost all existing nuclear generation capacity is assumed to retire between 2025 and

2050.[10] However, 29 GW of new nuclear capacity is projected to be added between 2025 and 2050. The share of renewable energy is also projected to increase from 7% and 9% throughout the projection period.

End-Use Energy Demand

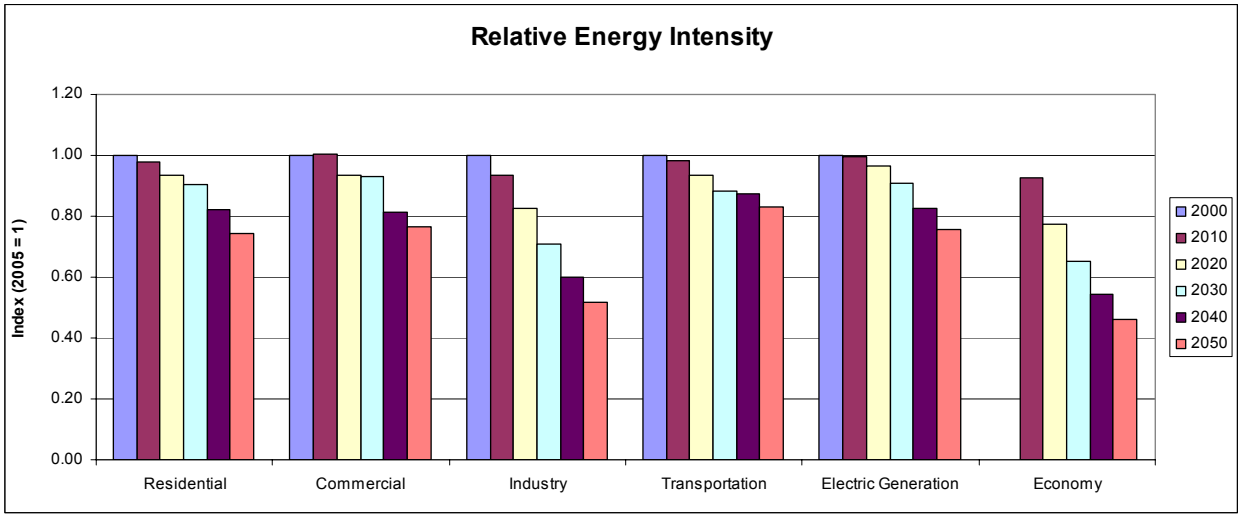
The sectoral breakout of energy use, shown in **Figure A-3**, demonstrates that commercial buildings and transportation energy demand is projected to increase most rapidly, at 1.2% and 1.1% per year respectively, from 2005 to 2050; while residential and industrial energy demand increases most slowly, at 0.4% and 0.6% per year, respectively. The growth rates in energy consumption are a function of the opposing trends of increasing end-use energy-service demand and improvements in the efficiency of technologies that satisfy this demand, as well as macroeconomic shifts toward less energy-intensive industries. This phenomenon is best illustrated by examining the energy intensity of the economy. **Figure A-4** shows the relative energy intensity for different end-use and conversion sectors and the economy as a whole.



Note: consumption totals include electric generation and distribution losses

Figure A-3. Energy Consumption by Sector

[10] The nuclear generation retirement schedule was derived by examining reactor-license expiration dates and applying one 20-year extension where applicable.



Note: Residential index is primary energy excluding misc. use per household; Commercial index is primary energy use excluding office equipment and misc. appliances per square foot; Industrial index is total primary energy per unit output; Transportation index is light duty vehicle primary energy per mile traveled; Electricity index is non-renewable average heat rate; and Economy index is total primary energy per unit GDP.

Figure A-4. Relative Energy Intensity by Sector

As shown in **Figure A-4**, our Reference Case projection indicates that the energy intensity of the economy (which we've defined as total primary energy consumption per $ of GDP) is projected to fall by more than half by 2050. This decrease reflects both a continued shift toward a service-based economy, as well as increases in energy technology efficiency. End-use efficiencies are projected to increase throughout the economy over the projection period as new, more efficient capital stocks are purchased to replace existing equipment and to meet new demand. The Reference Case technology database includes technologies that are expected to become available in the future, as well as those that are currently on the market. For example, more efficient electric heat pumps and light-duty vehicles are assumed to become available throughout the projection period. The technical and economic data associated with these technologies are derived from a variety of sources, but rely most heavily on the NEMS database.

The residential energy intensity index shows significant improvements in energy use per household. However, the residential index excludes "miscellaneous demands," the fastest growing segment of residential energy demand. The miscellaneous demand category includes electric devices such as home computers, TVs, microwave ovens, as well as devices such as gas lamps and swimming pool heaters. Because these service demands are growing faster than the sector as a whole, their energy use per household actually increases over time. Thus, the inclusion of miscellaneous demands in the calculation of residential energy intensity would obscure the efficiency gains being made in other residential service demands. While these miscellaneous demands are excluded from the chart, they are modeled within MARKAL.

The commercial energy intensity index shows significant improvements in energy use per square foot. However, as with the residential sector, this calculation excludes the fastest-growing demand categories; office equipment and miscellaneous commercial appliances. The inclusion of these demand categories would result in relatively constant commercial energy demand per square foot.

The industrial-sector efficiency index shows dramatic declines in energy intensity, due to a shift from energy-intensive industries to nonenergy-intensive manufacturing, as well as improvements in process efficiency. Between 2005 and 2050, nonenergy-intensive manufacturing output is expected to grow at twice the rate as energy-intensive industrial output. This shift in output exaggerates the decline in energy intensity. However, in the transportation sector, consumer preferences for more powerful engines, and a continued shift from passenger cars to SUVs, limit gains in overall efficiency.

In the power-generation sector, the efficiency of nonrenewable generation is expected to increase as older, less-efficient fossil steam units retire and new high efficiency gas combined cycle and IGCC capacity is built. Electric generation by type is shown in **Figure A-5**. Natural gas-fired generation is projected to increase its share of total generation from about 19% to 26% over the projection period. Coal-fired generation remains the largest source of electricity at 51% to 59% of total generation. Due to significant retirements of existing nuclear capacity, the share of nuclear generation falls from 20% to 4% of generation in the projection period. Renewable generation is relatively constant at 10% to 11% of total generation.

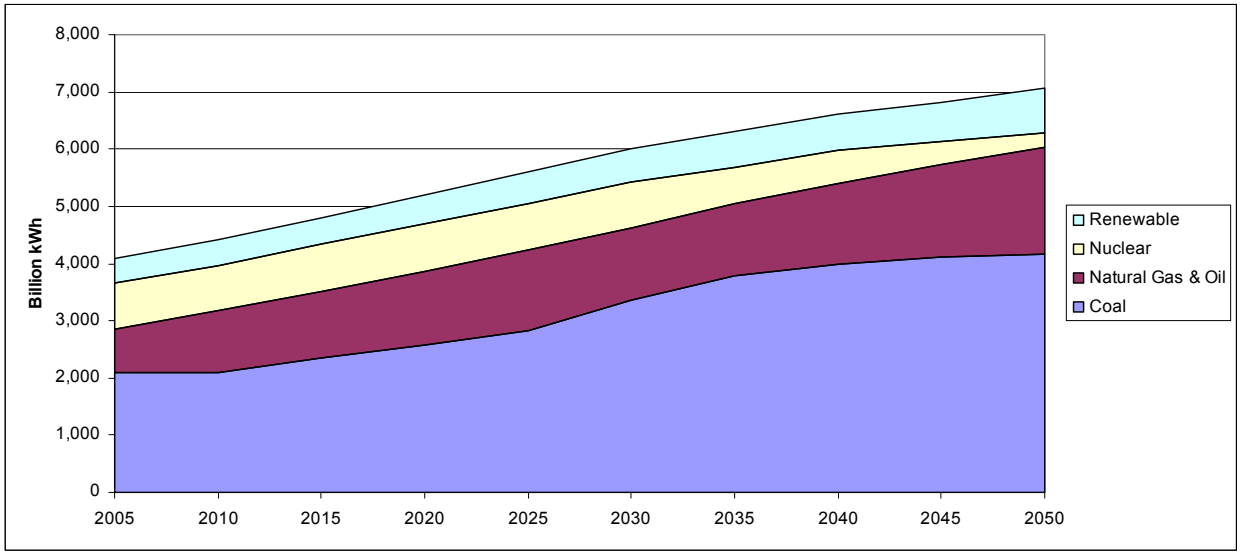


Figure A-5. Electricity Generation by Type: Reference Case

While both natural gas and coal-fired generation show increased efficiency, fossil fuel use for electric generation increases by 60% during the projection period. Such an increase in coal and natural gas demand for power generation is dependent on the availability of these resources. However, potential reduction in supply, such as changes in the outlook in natural gas supply, would necessitate a significant change in fuels used for electric generation.